# Pierre Auger Observatory
# Surface Detector micro-TPCB

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## 1. Introduction

The microTPCB serves as a wiring nexus for the solar power system, the batteries and the unified board (UB). It also provides analog signal conditioning for the quantities which need to be monitored for the understanding of the operation of the solar power system and provides fusing to prevent a catastrophic short circuit involving the batteries.

## 2. microTPCB specifications

The table below summarizes the ranges, resolution and quantities to be measured[1].

| Quantity | Range | Minimum Resolution |
|---|---|---|
| Battery + Voltage | 0-36 V | ± 0.12 V |
| Battery Center Voltage | 0-18 V | ± 0.12 V |
| Load Current | 0-1 A | ± 0.012 A |
| Solar Panel Voltage | 0-50 V | ± 0.12 V |
| Solar Panel Current | 0-5 A | ± 0.125 A |
| Battery 1 Temperature | * | ± 2 °C |
| Battery 2 Temperature | * | ± 2 °C |

The connection to the UB is made using a DB15HD connector with the pinout shown in the table below. The impedance of all inputs is 10Kohms in parallel with 100nF and the range is 0-5V with 12 bits resolution. So all the quantities must be adapted and conditioned before routing them to the UB.

| Pin | Signal | Comment |
|---|---|---|
| 1 | +12 V | 10 ohm output impedance; reserved for power feed to future |

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|---|---|---|
| | | sensors (e.g. water level) |
| 2 | +12 V | 1 Kohm output impedance; for a temperature sensor |
| 3 | BATTCENT | Battery center tap voltage, scaled to 0-5V |
| 4 | +12 V | 1 Kohm output impedance; for a temperature sensor |
| 5 | +12 V | 1 Kohm output impedance; for a temperature sensor. |
| 6 | GND | Unified board system ground. |
| 7 | EXTTEMP | Battery temperature current sensor return, AD592 (1 microamp/K). For an optional external temperature sensor. |
| 8 | LOADCURR | UB load current, scaled 0-5V. |
| 9 | BATTEMP1 | Battery temperature current sensor return, AD592 (1 microamp/K). |
| 10 | BATTEMP2 | Battery temperature current sensor return, AD592 (1 microamp/K). |
| 11 | WATLEV | Reserved for water level sensor or other future sensor, 0-5V. |
| 12 | BATTOT | Battery positive voltage, scaled 0-5V. |
| 13 | SPVOLT | Solar panel voltage, scaled 0-5V. |
| 14 | SPCURR | Solar panel current, scaled 0-5V. |
| 15 | DACOUT4 | Reserved for future use. |

## 3. Hardware Description

The TPCB consists of:

- Two two layer boards.
- Seven difference amplifiers for buffering and filtering voltage and current measurements.
- Two high side current shunt monitors for current measurements.
- Internal power supply.
- Associated general components.
- AMP DB15HD connector for routing signals to the UB.
- BUCHANAN 282813-2 connector for UB power.
- MOLEX 42820-2212 for solar panels.
- MOLEX 42820-4212 for batteries load current and solar panels charge current.
- MOLEX 39-30-1042 for external sensors.
- MOLEX 39-30-1082 for batteries signals and sensors.
- SAMTEC-ESQ-105-34-GD for boards interconnection.

The main goal of this implementation of the microTPCB is to achieve both good performance and reliability at low cost and low power. The basic idea is to keep the complexity to a minimum so the design is performed only with two layer boards. In addition, almost all components are though-hole type easily found in Argentina.

The microTPCB extends into two boards because the necessity of having all the connectors in the same side of its enclosure box. For this purpose there is a HD10 type connector between the two boards.

The amplifiers are the dual, single supply, rail to rail, low power AD822AN with 8PDIP package from Analog Devices. They are used in buffering and filtering the measured voltages and currents. The filters have a cut-off frequency of 10Hz (100msec time constant) and a roll-off slope of 40dB/dec. This is sufficient to attenuate a full range 1KHz component below ½ LSB.

In order to measure the currents there are two high side current shunt monitors INA168 from Burr-Brown. These components are the only ones of SMD types because there are no similar products available in the market with PDIP package. They are rated up to 60 V high side voltage.

The current measurements are done by 1% shunt resistors on the high side and the outputs of the monitors are fed to also 1% resistors that convert them in proportional voltages. The current measurements have an extra time constant added by the current monitor and associated circuitry. The voltage measurements are done by 1% resistors dividers buffered by the filter stage.

The internal power supply is a high efficiency, step-down switching regulator LT1676IN8 with 8PDIP package from Linear Technology. It transforms 24 Volts from the batteries to 5 Volts for the internal use of the microTPCB. This regulator has an ability to withstand power surges on batteries up to 60 volts and to operate with voltage across both batteries as low as 7.4 volts.

The microTPCB overlays the temperature and external sensor lines only routing them to the UB.

All the components, except the INA168s, are though-hole devices. All resistors are 1%, 1/4W metal film resistors. The capacitors are 10% ceramic or tantalum in each case.

Although the amplifiers are rail to rail, no real amplifier can "truly" reaches the rails. These devices present a saturation level of about 100mV with a 10Kohm load condition. In order to preserve the linear characteristic, the design shifts the maximum expected quantities to a value of about 4.8V instead of 5V. With this change there is no possible saturation and the loss of range is negligible. With this in mind when the final commercial resistor values will be adopted for the final production design, there will must be a little change in the readout software that takes into account the ~ 4.8V for full scale of the 12 bits converter instead of 5V.

## 4. Specs

The microTPCB consumes a maximum of 300mW. The internal circuitry consumption is 100mW and the 200mW remaining are due to the dissipation in the load current measurement shunt @ 1A. The power dissipation due to the solar panel current measuring is not had in account as this power does not come from the batteries.

As the microTPCB spans the quantities over almost the entire 5V range of the converter, the expected resolution is of about 12 bits. Strictly, as said before, a 4.8V full scale does not represent a big loss of range (about ½ bit). Thus the expected resolution is in the order of 0.03%.

A table of the absolute accuracy is shown below. These errors take into account the resistors tolerances and temperature drifts of the active parts. All the errors shown in the table can be drastically reduced using more costly 0.1% resistors. So this solution has to be studied.

| Quantity | Absolute accuracy |
|---|---|
| Battery + Voltage | 1.4% |
| Battery Center Voltage | 1.4% |
| Load Current | 1.75% |
| Solar Panel Voltage | 1.4% |
| Solar Panel Current | 2.5% |

[1] J.Beatty and P. Clark. Surface Detector micro-TPCB Specification. May 10, 2002.